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OF THE

Elisha Mitchell Scientific Society

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ISSUED QUARTERLY

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J. W. LASLEY, JR.,
Recording Secretary.

THE NATURE OF THE INDIVIDUAL IN THE ANIMAL KINGDOM*

By H. V. Wilson.

I believe that many of us think of the animal body as too unique a thing, as something cut out, so to speak, from the world of matter in too fundamental a fashion. If we turn to the inorganic world we find, to be sure, individuals there—crystals, for instance; but we recognize that the individual crystal owes much of its characteristic detail to what we call accident; that is, the same matter which forms one crystal might have formed two, or, on the other hand, only a fraction of a larger one. Thus the crystal, as an individual, is something fortuitous and secondary. It is the substance of which it is composed and which determines the character of the crystal that is more important.

An analogous viewpoint, it seems to me, is the rational one with respect to animals. It is the specific substance rather than the individual mass that we are investigating when we study biology. It is the properties of dog-protoplasm, for instance, of dog-plasm as we may call it, or of sea-urchin plasm, etc., that we need to discover and classify. Individual animals concern us only in so far as they are lumps of specific substances, of species-plasms. The task of the biologist is then analogous to that of the chemist. Each must determine the properties of certain kinds of matter and the sequence in which they appear, that is, their relations of cause and effect.

My contention is, then, that biology deals at bottom with a group of excessively unstable substances, the protoplasms, the various kinds of living substance, both such as are found in nature and such as are experimentally producible. The distinctive properties of these substances as we know and learn them today, whatever their ulterior nature may be, do not fall in the established categories of physico-chemical phenomena, but reveal themselves as responses to stimuli, responses which express themselves in growth, differentiation, and

*A lecture delivered, as Southern Exchange Lecturer for 1915-16, before the Philosophical Society of the University of Virginia, April 8, 1916.

reproduction, in the physiological processes of the body maintaining itself for a time as a concrete mass, and in the changes leading to old age and death, or in some of the lower forms leading not necessarily to death, but to a reversal of ordinary development whereby the body as a whole or in spots passes back into an embryo-like phase.

Some such point of view has in a measure long been held by many biologists. Spencer gives expression to it in his hypothesis of "physiological units" and his consideration of the nature of organic regeneration (1864-67). It is implied and in various passages distinctly maintained by Haeckel in his *Generelle Morphologie* (1866). It was presented with great directness and completeness by Mrs. E. A. Andrews in her remarkable book *The Living Substance* (1897). The histological side of Mrs. Andrews' book, original as it is, is equaled in importance by her treatment of the fundamental structure of protoplasm in relation to its biological properties (*cf.* Heidenhain, 1907, p. 493). In the addendum to this lecture other important references are given.

Nevertheless it seems to me that this way of looking at living things is too frequently obscured by the very facts that we amass, and perhaps also by the complex hypotheses which we invent. This conception of individual bodies as mere masses of specific substances is supported by a long series of discoveries, some old, some recent. I propose to describe a few of them.*

The kinds or grades of individual occurring in nature. Let us consider for a moment the kinds or grades of individual occurring in nature. An ordinary metazoan animal, hydra, earthworm, fish, man, is in technical language an individual of the second order, in that the body is here composed of multitudes of primary elements, the cells. The protozoa, amœba, for instance, are minute free-living forms, the body of any one of which is analogous to a metazoan cell. These, then, like the cells, are individuals of a lower grade than a hydra or a dog. They are individuals of the first order. Again we find, especially in the coelenterates, the group which includes the corals, sea-anemones, hydroids, etc., individuals of a higher order than those animals with which we are chiefly familiar. In these forms the first

*The illustrative diagrams given in the lecture are here omitted.

individual gives rise by budding or incomplete division to several, often to large colonies, the members of which remain connected and are mutually dependent. Such colonies may undergo a high degree of integration, as in the siphonophores. The "Portuguese Man-of-war," for example, which we all recognize as an individual animal, is yet anatomically a colony of forms, each comparable to a hydra. It is an individual of the third order.

We thus learn that the formal or morphological conception of the animal individual is one which varies with the group. In the protozoa the "individual" is one thing, in the vertebrates another, and in the siphonophores still another.

Propagation of animals from cuttings. Passing to the field of experiment, let us first consider the propagation of animals from cuttings. Such facts fall under the rubric of "regeneration," using the term in a wide sense.

In the protozoa, Stentor is especially favorable for experimentation. The animal is trumpet-shaped, with a greatly elongated "beaded" nucleus, and when expanded may reach one millimetre in length. It may easily be cut in pieces. If this is done, the pieces that contain portions of the nucleus remodel themselves into the characteristic shape and become individual Stentors (A. Gruber). Similar experiments have been performed on many protozoa.

In the sponges Cavolini (1785), and especially Oscar Schmidt, in the course of his studies on Adriatic forms (1862—), showed that if a single animal be cut in pieces, the pieces heal and become new individuals. Since his time various experiments made on a large scale, notably those carried on in recent years by the U. S. Bureau of Fisheries,* have demonstrated that the method is of commercial value.

The experiments of the Abbé Trembley on hydra are classics. Hydras are small fresh-water forms belonging to the group of coelenterates. The body is an elongated sac. The mouth surrounded by tentacles is at one end and opens into a digestive cavity. The body wall is made up of two layers of cells, some of which are muscular,

*A Practical Method of Sponge Culture. By H. F. Moore. Proc. Fourth Intern. Fishery Congress, 1908.

others nervous, others secretory, etc. Trembley showed in 1740 that if a hydra be cut in pieces the pieces become new hydras.

Within a year Trembley's experiments were followed by many others, and it was shown that marine polyps and star-fishes may be propagated in this way. Bonnet demonstrated (1741) that the method is applicable to forms as high as the earthworm family. He cut a fresh-water form, Lumbriculus, into several (three to fourteen) pieces, and found that almost all remodeled themselves into little worms. In recent years these beautiful experiments on the regenerative capacity of animals have been greatly extended and the phenomena subjected to close analytical study, in this country especially by T. H. Morgan and his students.

From such experiments we learn that the "individual" is not essentially unique. We cannot say of him, "He is there, or not there." For, being "there," with a stroke of the knife or scissors we make out of one, two. The interest attaching to such facts is great. Their significance for the conception of individuality is obvious.

Reduction-phenomena. Some of the phenomena classed under the head of "involution" or "reduction" are of importance for our inquiry, especially the notable discoveries of Driesch on ascidians and the facts that have been worked out on sponges. I restrict myself to the latter.

It has been shown (H. V. Wilson) on one of our common coastal forms (Stylotella, one of the monaxonida) that if the sponge be kept in confinement under conditions that are unfavorable and yet not immediately disastrous, the sponge body quickly gives up much of its structure. The apertures through which water enters and leaves the sponge close up, the system of canals ramifying through the body is suppressed in large measure, the skeletal arrangement is simplified, and the little chambers lined with flagellated cells which maintain the current of water necessary for a physiologically active life disappear, the flagellated cells becoming amœboid and creeping away into the general mesenchyme. All this appears in the light of a behavior that is useful. The sponge endeavors, so to speak, to protect itself against the bad water of the aquarium. If restored to good conditions at any time, differentiation quickly takes place and the body resumes its typical structure. But if the unfavorable conditions persist the sponge ceases to act as an individual. A large part of it

dies. Cells creep together in spots and form little masses easily distinguishable by their bright color. Microscopic study shows that in such masses the living tissue has passed into a simple phase, owing to which doubtless it is able to resist the environment. If now these minute masses are cut out and restored to well aerated sea-water, they quickly transform, each into a little sponge. Essentially the same facts have been made out on fresh-water sponges (K. Müller) and on calcareous sponges (O. Maas). The regenerative masses formed in this way are in many respects analogous to the reproductive bodies known as gemmules which are normally formed in the life cycle of many sponges. Much still remains to be learned of the relative parts played in their formation by the de-specialization of tissue elements and by phagocytosis on the part of amœbocytes. For us the experiments are interesting in that they show so plainly that the individual body may as a whole die, but remain alive in spots, the flesh here passing into a condition of unspecialized regenerative tissue (technically "totipotent").

In speculating as to the underlying events that go on in a sponge which thus abandons its individuality and breaks up into masses each capable of producing a new individual, we first ask ourselves what keeps a mass of cells together as an individual? It is apparently the constant exchange of stimuli between all the various parts of the body, to which this is due. If a part of the body is for one cause or another isolated from this traffic of stimuli, it dies or passes into the condition of regenerative tissue. Using the imagination a little, we may say that the cells cut off from the usual intercourse with one another tend to revert to the primitive condition of unspecialized bits of protoplasm capable of doing all things (totipotent). Some actually attain this low, but now useful, level. Such huddle together and form masses that succeed in resisting the unfavorable environment. With the return of a favorable environment the powers of such masses become active and they now transform themselves each into a new organism.*

*Wilson, H. V. 'A New Method by Which Sponges May be Artificially Reared," *Science*, June 7, 1907; "On Some Phenomena of Coalescence and Regeneration in Sponges," *Journ. Exp. Zoology*, vol. 5, 1907; "Development of Sponges from Dissociated Tissue Cells," *Bull. U. S. Bureau of Fisheries*, vol. 30, 1911; "On the Behavior of the Dissociated Cells in Hydroids, etc." *Journ. Exp. Zoology*, Vol. 11, 1911. Child, C. M.: "Die physiologische Isolation von Teilen des Organisms, etc.," *Vorträge und Aufsätze u Entwmech. d. Organismen*, Heft 11, 1911.

Development from dissociated cells in sponges and hydroids. Allied to the foregoing is the phenomenon of the development of an organism from dissociated cells. We now know that sponges and hydroids may be broken up into microscopic bits of protoplasm most of which represent the cells of the original organism, and that such bits (dissociated cells), if given the opportunity, will reunite and form masses that transform into sponges or hydroids respectively (H. V. Wilson, K. Müller, J. S. Huxley, De Morgan and Drew, C. W. Hargitt). It is not impossible that this cellular behavior will be found to hold true of still higher organisms, at any rate of those which like polyzoa and ascidians include in their cycle of development asexual methods.

The treatment is simple. The animal is cut into pieces and these teased up into their constituent cells, or, better, pressed out through fine gauze. The cells stream through the gauze like sediment, and may be sown on glass plates, etc. They crawl together like the lymph corpuscles of a sea-urchin, forming plasmodial masses that exhibit amœboid phenomena. These metamorphose, as said. In the case of sponges, control of size is possible. That is, a large or small sponge may be made as desired. In the case of hydroids, size is not under control, for it is here a fixed specific character. The plasmodial masses may, of course, be made large or small, but the metamorphosis is carried out in such a way that hydroid tubes (and polyps) of a constant size are formed from them.

From such experiments it seems proper to conclude that the cells of the body, when their connections with one another are forcibly broken, pass into a generalized state in which they are attracted to one another. Thus they combine to form masses which then develop the peculiar features of that kind of protoplasm, viz., they restore one or several such animals. We may say that the particles of the species plasm fuse, and the mass so produced "forms out," metaphorically crystallizes out, at one or more centers. In such lower forms the permanency of the individual, its uniqueness, is obviously very secondary, while the species-substance is easily seen to be the primary, the fundamental thing.

Fusion and grafting in lower adults. In the lower forms to which reference has been made not only may the body be subdivided, and

so several bodies made out of a single one, but the opposite process may also occur, wherein two bodies or parts of two bodies fuse to form one. (*a*) Thus two adult sponges may grow together, forming a single sponge (Cavolini, Grant, Vosmaer). (*b*) Pieces of two or several hydras, hydro-polyps, or medusæ (Trembley, Wetzel, C. W. Hargitt, Miss Peebles, Miss King) may be fastened together with the resultant formation of a single individual. (*c*) Two earthworms may be divided, and the head end of one sewed to the tail end of the other (Joest). The wound heals, permanent union between the two pieces is made, and thus we have a new "individual" composed of parts of two former individuals. (*d*) In the experiments where dissociated cells of sponges or hydroids are made to fuse together and form new individuals, it matters not whether the cells which combine to form a new sponge or a new hydroid have come from one or from many former "individuals."

All such facts well illustrate the conception that the animal body is not something mysteriously unique and individualistic in a sense in which nothing else in the world is so. We see that its individualism is something not radically different from that of inorganic bodies, in so far at least as it is, like the latter, only the form which a specific substance assumes.

Regeneration and fusion in embryos of higher animals. With higher adults the case is different. We cannot cut a vertebrate animal, frog, or salamander, *e. g.,* in two and get two frogs or two salamanders. Nor can we sew the front end of one frog on the tail end of another and thus make a new frog. But what we cannot do with the adult can be done with the young. And here again, as in every nook and corner of biology, we get an application, an illustration, of the biogenetic law, of the great generalization that embryos of higher forms resemble lower adults. The resemblances are in part anatomical, or morphological as we say, and of these we know a great deal. But in part they are physiological, that is, the embryo of the higher form *will do* what it cannot do in the adult form but what the lower adult can do easily. Of these physiological resemblances we know little. What we have learned suggests how much of interest and value there is to be found out.

In the case of our own subject of inquiry—individuality—we learn that while the individuality of the higher adult is relatively fixed, that of the embryo is, in very many forms, on the same plane as that of the lower adult. Stating the facts more definitely, we may say that (*a*) The embryos of higher forms may be subdivided with the production of two or several organisms from a single one; (*b*) Two or several embryos may be fused together with the production of a single larger one; or (*c*) Components of two individuals may be combined to form a single body. With respect, then, to regeneration and fusion, such embryos behave much as do lower adults.

Let me briefly describe some of the concrete facts:

(*a*) If the sea-urchin egg be allowed to start its development and to divide into two cells, and if these two cells are now forcibly separated they will develop independently of each other. Each continues for a time to develop as if it were a half of a whole. Thus, instead of forming a sphere (blastula) it forms one half of a sphere. The half-sphere closes, however, forming a whole sphere (blastula). This invaginates to form the usual two-layered sac or gastrula. And this gradually develops into a pluteus, the characteristic swimming larva of the sea-urchin. The pluteus has the typical structure, but is, of course, smaller than the normal (Driesch).

The same experiment may be performed on vertebrates. In the newt (Triton), for instance, the egg of which is of considerable size, let us suppose that development has begun and the egg has divided into the first two cells. If now a fine thread be tied round the egg so as to separate the two cells, each develops into a whole but small larva (Herlitzka). If the egg be merely constricted, it develops not into two larvæ, but into a double-headed larva (Spemann).*

The eggs of very many other forms, medusæ, teleost fish, amphioxus, frog (under certain conditions) behave in a similar way. In certain groups, however, ctenophores (Driesch and Morgan), and especially the mollusca (E. B. Wilson, Crampton) and ascidians (Conklin), we now know through some of the most admirable of modern embryological investigations that the egg behaves in a different manner from the foregoing. Here, if the cells (blastomeres) of

*The cases in which other results follow are due to a different position of the first cleavage plane, and in no way impair the argument.

the segmenting ovum are separated, each does not give rise to a whole embryo, but only to a part of one. In general, we may say that a separated blastomere in these eggs tends to give rise to what it would have formed in the normal development. The protoplasm of the egg is specialized in that it is divided up into parts which in some forms are even optically distinguishable. These become the different cell groups that give rise to the great organs of the body. This organization of the egg is not, however, to be interpreted as meaning that the egg is a mechanism made up of parts that are distinct and self-propagative through a series of generations. For the cytoplasmic regions, "organ-forming substances," are not hereditary as such. What is hereditary is the habit of developing them. They are not present, or at least there is no reason for believing them present, in the young egg. They seem, on the contrary, to be formed anew in each individual development. They fall then in the class of differentiations made in the course of ontogeny. Their peculiarity is that they are formed so early. As to their precise nature, they may represent early specializations of the actual living substance, specializations which in extreme cases are not reversible (ascidians, apparently), or they may be largely forms of deutoplasmic material essential to the development of particular organs. The young egg in such species is comparable in this matter of individuality or integration with the egg of the jelly-fish or echinid.

Digression. Reversible specializations of the mass of specific substance constituting an egg are familiar. Thus the first two cells of the sea-urchin egg represent the two halves of a hollow ball, as is shown by their development immediately after separation. But this specialization into halves is later given up, and in consequence the half blastula becomes a whole. A similar reversal of specialization may be induced in the frog by turning the egg upside down in the two-cell stage (O. Schultze), or, as in Morgan's experiment, by first killing one of the blastomeres and then turning the egg upside down. Driesch visualizes such phenomena of "regulation" as due to a rearrangement of the particles of the protoplasm,* an explanation which is probably close to the truth.

**Analytische Theorie*, pp. 25, 149; *Science and Philosophy of the Organism*, vol. 1, p. 66 *et seq.*

(*b*) In the experiments of the preceding section the egg or embryo has been divided. Conversely, two eggs or young embryos (blastula stage) may be made to fuse. This has been shown (Morgan, Driesch, Goldfarb, DeHaan) to hold for the sea-urchin egg. Fusion results sometimes in the production of double monsters, viz., abnormal embryos showing some degree of duality. But in other cases the resulting individual (blastula, gastrula, pluteus larva) exhibits the normal unity of structure and is simply larger than the type. Fusion between eggs, embryos, or larvæ, with results essentially similar to the above, has been observed in sponges, medusæ, and nematode worms.

(*c*) The fusion of *parts* of different individual embryos to form one is strikingly shown in the case of the frog. Born discovered that if embryos in an advanced stage of development (just before or after hatching, when they measure in *Rana esculenta* about three millimetres in length) are cut in half, the head half of one embryo may be pasted to the tail half of another, and permanent union will take place. The composite embryos formed of components of two (former) individuals, grow, feed, and differentiate like the normal, becoming large tadpoles. One such, in Born's experiments, metamorphosed into a frog.* Owing to the ease with which the young embryos fuse at the cut surfaces, Born was able to combine them, or parts of them, so as to produce some very bizarre monsters which lived and grew for a surprising length of time. Harrison in similar experiments even combined components of different species, and thus obtained a frog the head half of which was made up of *Rana virescens* material, the trunk half of *Rana palustris* material.†

A like synthesis of one body out of components of two has been carried out by Crampton on moths. Crampton cut the pupæ in two and pasted parts of different individuals and, indeed, of different species, together. The components unite, although union is confined to the more superficial structures. The composite pupa metamorphoses into a moth, or when components are combined in bizarre fashion to what may be called a moth complex.

These results of experimental embryology throw light on the nature of "identical twins" and many of the "monsters," sometimes of such disconcerting aspect, of human embryology.

*Archiv f. Entw.-mech., 4, p. 393.
†Archiv f. Entw.-mech., 7, pl. XI.

In conclusion, I may once more restate the generalization to which all the various kinds of facts referred to in the preceding lead up. It is that the animal body, our body, *e. g.*, is only the expression of the active forces of a specific substance, a specific protoplasm. Its uniqueness in the higher forms is deceptive. It falls then in the same great category of objects as a crystal. In making this plain, Haeckel and Spencer emphasized a thought of fundamental importance, the value of which is not diminished by the fact that the category is a wide one and therefore susceptible of continued division.

Addendum.

(1) A germ cell is then a lump of a specific substance, which under appropriate conditions will go through a certain cycle of changes. Out of harmony with this conception is Brücke's classic definition of the cell as "an elementary organism" (1861), recently supported by the late Professor Minchin, in opposition to the idea that it is a piece of a substance (1915). But the facts brought out by Whitman (1893), Sedgwick (1894), Mrs. E. A. Andrews (1897), Heidenhain (1907), and the data presented in the body of this lecture, show that cell formation in actual ontogeny is only a morphogenetic principle or method (*cf.* Sachs, 1882, p. 88; E. B. Wilson, 1902, and Heidenhain, *loc. cit.*, give the references to Sachs's later and more explicit discussions), that cells are only subordinate regions of the whole mass, and that the egg cell is potentially an organism, or two, or a fraction of one. Thus the implication of uniqueness in Brücke's phrase cannot be sustained. Cells between which transference of cytoplasmic material takes place (Mrs. Andrews, H. Spencer), which fuse with one another or break connection, and the nuclei of which are all alike as is shown by shifting them about (O. Hertwig, Driesch), are obviously only regions or free lumps of a substance.

The fixed individuality of the cell is emphasized in the preformation theories which represent the egg cell as a machine, as a compound machine, in fact, made up of little machines (determinants), each of which transforms itself into a particular kind of part (Weismann) or a particular part (His) of the adult organism. In Weismann's theory chromatin particles, in His' cytoplasmic particles represent the determinants. Weismann's theory is of course strictly pre-

formational in that the determinants are hereditary (persistent through the generations as such). His' theory also falls in the preformational class if we look on the germinal particles as hereditary, but not so if we regard them as differentiations made anew in each egg.

But as Driesch, O. Hertwig, Spencer, and many others have pointed out, the facts negative the idea that the egg cell or organism into which it grows is a machine. The power to restore amputated parts and the power of a part to develop the typical structure in its entirety, are widespread. Machines do not behave in this way, but substances (crystals) do. Moreover, there are probably no independently variable parts in the hereditary constitution of an organism. That is, no one character changes by itself, but the whole constitution changes (Spencer, 1898-99, vol. 2, p. 622). A machine made up of determinants would not behave in this way, but a substance would.

(2) But what is the nature of this lump of specific substance, the germ cell? Are its properties such that we cannot believe they are all material? Is there some extra-material force bound up in it, a teleological *entelechy* which sees the end to be reached, and directs the atoms and molecules towards that end? Is the chain of events that constitutes ontogeny a phenomenon so singular, and the facts of organic restitution so radically different from restitution in crystals, that with Driesch we must go outside of matter for an explanation, and acknowledge the presence of the "archæus, vital principle, *nisus formativus*," against the charge of incorporating which Spencer defends his theory of physiological units (Letter of 1868 in 1898-99, vol. 1)? There seems to be no reason for doing so. The objective question is, Are the phenomena orderly and predictable? If so, they are no more supernatural than anything else. They are only the reactions of higher forms of matter to the environment.

This appears to be the position of Driesch in his *Analytische Theorie* (1894). For while he here argues for the control of ontogenetic processes by a teleological power (p. 147 *et passim*) and expressly says that "self-regulation" (Roux) is a teleological power (p. 150), he nevertheless says also that it is analyzable into architectural and physical components (p. 154). This is manifestly treacherous ground to linger on.

(3) We may conclude, then, that the egg is a piece of matter with certain properties. It belongs in the protoplasms, "the organic compounds which we call living forms" (Haeckel, 1906 (1866), p. 140). In our study of these we move on parallel lines with chemistry (Hertwig, 1912, p. 155) in so far as both biology and chemistry seek to discover the properties of the *kinds* of matter. The properties of the protoplasms which concern biology are their responses to stimuli (W. K. Brooks, 1899). Physical and chemical knowledge of them is interesting chiefly as it contributes to a better understanding of what they can and may be expected to do and how they may be changed.

When biology has learned infinitely more about the peculiar properties of the protoplasms than is now known, and chemistry and physics have in like degree increased their power over unorganized matter, chemistry may synthesize some simple form of living substance, analogous perhaps to the "living granules" of recent histology (Heidenhain). Biology then, with the aid of the other sciences, may make these "living albumens" interact upon one another in such wise that adaptive artificial protoplasms result (*cf.* W. K. Brooks), the members of the series becoming more and more complex with continued combination. This is for the distant future.

(4) The concept that an organism is primarily made up of a specific plasm, and the germ cells are only small lumps of the plasm, provides in itself a sufficient working basis for many classes of investigations. The concept is noncommittal as to the fundamental structure of protoplasm in relation to its heritable properties, and is indeed independent of future discoveries in this field. It is used all the time today and will continue to be used whatever we may come to think of the significance of cell boundaries and intra-cellular parts.

(5) Nevertheless, we inevitably ask ourselves, Is the living part of a germ cell, the part which we designate a specific plasm, a single substance made up of like molecular complexes after the fashion of a high organic compound?

It is so conceived in Spencer's hypothesis (1864-67; 1898-99). Spencer pictures a specific protoplasm as made up of "physiological units," all alike and each endowed with the heritable properties of

the species. The units are in physiological continuity throughout the body, such that what affects one part of the organism affects the whole; and are molecular complexes intermediate between ordinary chemical molecules and the cells. The physiological continuity which Spencer postulates is obviously analogous to the continuity which exists in any molecular substance.

Nägeli's micellar hypothesis (1884) elaborates the essential idea of Spencer's theory. There is a specific plasm for every organism. It is made up of molecular complexes, the micellæ, which, however, are simpler than Spencer's units, for, unlike the latter they do not grow and divide. They are combined in a definite fashion to form a reticulum of cords which extends throughout the body. Every cord of this reticulum, representing a group of micellæ, is endowed with the heritable properties of the species. The specific plasm receives the useful name of idioplasm. Combined with it is a nutritive plasm.

Wiesner (1892) and various others, Heidenhain (1907), Fick (1907), Reichert (1914), have developed Spencer's fundamental concept of a specific plasm composed of ultra-microscopic molecular complexes capable of growth and division.

The field is confessedly a speculative one. The actual structure of the living substance in relation to the realization of its potential properties, viz., to the "organizing process" which it undergoes in ontogeny, is unknown to us. As Spencer points out, his hypothesis of constitutional units only represents a "way of symbolizing the process so as to enable us most conveniently to generalize its phenomena" (1898-99, vol. 1, p. 373).

In such theories no detailed correlation is established between the fundamental, invisible structure which is deductively concluded to exist, and the visible differentiations of cells. They leave to one side, for instance, the nuclear behavior which modern cytology has discovered. There is, however, no actual contradiction between such discoveries and this class of theory. For it *may* always turn out that all optically distinguishable cellular structures are only the more or less persistent, but in final analysis replaceable, products or differentiations of a uniform idioplasm. Nuclei, to be sure, in amitosis, and chromatin, sometimes perhaps chromosomes, in mitosis appear to pre-

serve an independence throughout the cycles of cell division. Nevertheless, there is during mitosis a great interchange of material between nucleus and cytoplasm, which may indeed be one of the chief uses of mitosis in contrast to amitosis. Perhaps at this time cytoplasmic and nuclear material intermingle and reciprocally give up certain temporary peculiarities which they have acquired since the last equilibration episode. The chromatin would thus start out periodically afresh in the prophase as pure and concentrated (whence its staining properties) idioplasm. This idea is in accord with the observed facts as to constancy in number and shape of the chromosomes in a specific plasm, these being specific characters like any others. It is again not in contradiction with the existence of special chromosomes (sex chromosomes, *e. g.*), which influence metabolism, and hence the course of ontogenetic differentiation, in a particular way. Such would fall in the category of early idioplasmic differentiations, permanent sometimes through several generations, or as long as useful, but always reversible or replaceable; made at various times and in various ways in different species; to be looked on as physiological organelles that are differentiated anew by the idioplasm when needed. This view is in harmony, I believe, with the known histological and physiological facts of sex-determination. It is the logical conclusion if, with Spencer, Nägeli, and Mrs. Andrews, we assume that the idioplasm of an organism is a continuous and uniform substance.

(6) On the other hand, is the living substance or idioplasm not strictly a single substance, but a mixture in definite proportions (to be compared with a standard building mixture, for example) of somewhat similar but permanently distinct materials, nuclear and cytoplasmic, which are related perhaps phylogenetically? This is the view of Heidenhain (1907, p. 61, p. 495), who regards all optically distinguishable protoplasmic structures as having arisen ontogenetically or phylogenetically out of the fundamental substance, itself homogeneous in appearance and composed of molecular complexes, protomeres.

(7) Or are we to look with O. Hertwig and Strasburger (1884) and so many biologists on the chromatin as the true species substance

or idioplasm, and on the rest of the cell as a characterless but living material, a nutritive plasm? Whatever we may think of such a sharp distinction, the facts of cytology indicate that the chromatin is idioplasmic, whether or no anything else is. It is even permissible to go farther and to view the chromatin in a nucleus as a compound of unlike parts which have not the nature of Weismannian determinants, but which coöperate somewhat after the fashion of the smaller molecules that make up a molecular complex. They thus together constitute a substance, "anlage-substanz" of O. Hertwig, in which are potentially seated the specific properties; these latter being dependent both on the intrinsic nature and the arrangement of the chromatin particles (Hertwig, 1912, p. 399). The analogy is obviously with stereochemistry.

Morgan in a series of investigations summed up in a stimulating book (1915) has especially developed the conception of the living substance just referred to. The unlike chromatin particles, designated "bioplasts" in Hertwig's theory, he identifies as the Mendelian "factors." He and his associates find that the results of their extensive and notable breeding experiments are explicable on the theory that the "factors" are arranged in a linear series in the chromosomes, and that corresponding ones brought together in consequence of the fertilization of the egg are finally separated after a period of close association, during which they may exchange places in the chromosome complex, and pass into different gametes. The ordinary Mendelian "segregation" and many intricate combinations of characters are thus explained.

(8) It is well known and has often been said that the path of discovery is strewn with discarded hypotheses that once were useful, but have served their time. Many people unfamiliar with scientific research misinterpret the situation. In some way they have acquired too high a respect for the deductively reached "explanation." This to them constitutes the greatest triumph of the mind, and discarded theories therefore seem to bear witness against science itself. Whereas, as we all know, the really great and enduring result of the work of science is verifiable knowledge grouped and made accessible in the shape of generalizations.

In regard then to our subject, as in other fields, it is the objective facts, wherever the eye is keen enough to discern and the mind logical enough to state them, that will stand, whatever be the fate of any present-day theory as to the fundamental structure of the idioplasm, as to the way in which hereditary traits are represented in the germ cells (*cf.* O. Hertwig, 1912, p. 708).

(9) In Child's recent book (1915), incorporating the results of a long series of investigations, individuality is discussed from a standpoint different from that taken in the preceding lecture. Child deals with the difficult question as to *how* it comes that a germinal mass of protoplasm acquires the organization of an adult animal or plant. This question involves two: first, a phylogenetic one, how a plasm has come to have a particular set of biological properties; and, secondly, how the gradual organization which appears during the ontogeny is directed. In both cases a difference as to intensity of metabolism between regions of the mass is, he concludes, the chief factor. Axes are thus established along which metabolism grades down from high at one end to low at the other. Such "metabolic gradients" lead in phylogenesis to the axial differentiations of structure characteristic of an organism (piece of plasm); and in the ontogeny of a concrete mass to the orientation of the characteristic axes; thus in a fragment of planarian, a certain point of high metabolism becomes the head end.

Child, it may be added, conceives the organism, and germ cell, to be a mass of specific material (he designates it a "specific reaction system") the potencies of which are implicit in its physico-chemical constitution but not severally localized (p. 202).

University of North Carolina,
Chapel Hill, N. C.

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SOME ELEMENTARY VECTOR EQUATIONS

By J. W. Lasley, Jr.

§ 1. In the real plane it is often convenient to denote the points by number pairs. We agree that to every number pair there shall correspond a point. There are ∞^2 points in the plane. A relation connecting the coördinates selects ∞^1 of these, which lie on a certain locus. This relation may be expressed parametrically as,

$$x = \varphi(\mu), \qquad y = \psi(\mu).$$

The elimination of μ leads to

$$f(x, y) = 0.$$

§ 2. In the complex plane a point is denoted by a stroke or vector z from the origin to the point. Corresponding to every pair of numbers (x, y) there is a complex number $x + iy$, or z. If the x and the y are connected parametrically as in article one, we have,

$$z = x + iy = \varphi(\mu) + i\psi(\mu) \quad \ldots\ldots \quad (1)$$

which for various values of μ gives points on a locus in the complex plane. In what follows we shall mean by $\bar{z}$ the conjugate of z. Then,

$$\bar{z} = x - iy = \varphi(\mu) - i\psi(\mu) \quad \ldots\ldots \quad (2).$$

The elimination of μ from (1) and (2) leads to

$$f(z, \bar{z}) = 0.$$

§ 3. It is at times convenient to express

$$z = \varphi(t)$$

and

$$\bar{z} = \bar{\varphi}(t)$$

where by t we mean a complex $\cos\vartheta + i\sin\vartheta$ or $e^{i\vartheta}$, whose conjugate is its reciprocal and whose geometric significance is a turn, and by φ we mean that function obtained from

φ by changing every complex to its conjugate. These equations are in a sense analogous to those parametric equations given in article one, and t is a sort of complex parameter. The elimination of t leads to

$$f(z, \bar{z}) = 0.$$

§ 4. A right line in the real plane is given parametrically by

$$x = a + kb, \qquad y = c + kd$$

as in article two

$z = (a + kb) + i(c + kd) = (a + ic) + k(b + id) = A - kB$
where $A = a + ic$ and $B = b + id$.

Similarly

$$\bar{z} = \bar{A} + k\bar{B}$$

where $\bar{A} = a - ic$ and $\bar{B} = b - id$. $\bar{A}$ is the conjugate of A.

The elimination of k gives

$$z\bar{B} - \bar{z}B + \bar{A}B - A\bar{B} = 0,$$

or, more compactly,

$$c\bar{z} + \bar{c}z + d\bar{d} = 0$$

where c, $\bar{c}$, d, $\bar{d}$, are complex.

§ 5. The circle

$$x^2 + y^2 = a^2$$

is given parametrically by

$$x = a \cos \vartheta, \qquad y = a \sin \vartheta \ .$$

Now

$$z = x + iy = a \cos \vartheta + i \sin \vartheta = at$$

and

$$\bar{z} = x - iy = a \cos \vartheta - i \sin \vartheta = a/t$$

eliminating t

$$z\bar{z} - a^2 = 0 \qquad (a \text{ real}).$$

§ 6. Picard [1] makes use of the form

$$z\bar{z} + Az + \bar{A}\bar{z} + B = 0 \quad (B \text{ real})$$

as the equation of a circle in the complex plane. He uses this form to show that under the bilinear transformation

$$w = (az + b)/(cz + d)$$

circles are sent into circles. He makes no explanations of how the equation was got, but states that when the complexes are replaced by the sum of their real and imaginary parts the circle's equation in the real plane results. Now article three gives us a direct way of passing from this real plane form to the complex plane equation.

A circle whose centre is the point (a, b) has for its equation in the real plane

$$(x - a)^2 + (y - b)^2 = r^2,$$

or parametrically,

$$x = a + r\cos\vartheta \ , \qquad y = b + r\sin\vartheta \ .$$

Then $z = x + iy = (a + r\cos\vartheta) + i(b + r\sin\vartheta)$

$$z = (a + ib) + r(\cos\vartheta + i\sin\vartheta) = A + rt$$

also, $\bar{z} = \bar{A} + r/t$

eliminating t

$$(\bar{z} - \bar{A})(z - A) = r^2$$

or more compactly,

$$z\bar{z} + a\bar{z} + \bar{a}z + b\bar{b} = 0$$

which agrees with Picard's form since the product $b\bar{b}$ is always real.

§ 7. The ellipse

$$x^2/a^2 + y^2/b^2 = 1$$

is given parametrically by

$$x = a\cos\vartheta \ , \qquad y = b\sin\vartheta \ .$$

[1] Picard's *Traite d'Analyse*, page 462.

Then

$$z = a\cos\vartheta + ib\sin\vartheta$$

$$\bar{z} = a\cos\vartheta - ib\sin\vartheta$$

adding

$$z + \bar{z} = 2a\cos\vartheta$$

subtracting,

$$z - \bar{z} = 2bi\sin\vartheta$$

eliminating ϑ ,

$$b^2(z+\bar{z})^2 - a^2(z-\bar{z})^2 = 4a^2b^2$$

which when written

$$(z+\bar{z})^2/(2a)^2 - (z-\bar{z})^2/(2b)^2 = 1$$

has a fair analogy to the form of the hyperbola's equation in the real plane.

§ 8. The hyperbola

$$x^2/a^2 - y^2/b^2 = 1$$

is given parametrically by

$$x = a\sec\vartheta \ , \qquad y = b\tan\vartheta$$

So

$$z = \text{a}\sec\vartheta + ib\tan\vartheta$$

and

$$\bar{z} = a\sec\vartheta - ib\tan\vartheta$$

adding

$$z + \bar{z} = 2a\sec\vartheta$$

subtracting,

$$z - \bar{z} = 2bi\tan\vartheta$$

eliminating ϑ,

$$(z+\bar{z})^2/(2a)^2 + (z-\bar{z})/(2b)^2 = 1$$

which has a fair analogy to the form of the equation of the ellipse in the real plane.

§ 9. If we wish to pass from

$$z = \varphi(t), \quad \bar{z} = \psi(t)$$

to

$$f(z, \bar{z}) = 0$$

by elimination, we find at times that the elimination is not easily made. In many instances replacing t by its value $\cos\vartheta + i\sin\vartheta$ gives for ϑ an easier elimination.

For instance

$$z = b/t + t$$

$$z = bt + 1/t.$$

Here the elimination of t is more involved than the elimination of ϑ from

$$z = (1+b)\cos\vartheta + i(1-b)\sin\vartheta$$

$$z = (1+b)\cos\vartheta - i(1-b)\sin\vartheta$$

which are equations got from the above by replacing t by $\cos\vartheta + i\sin\vartheta$. In fact, the elimination proceeds as in article seven and gives

$$(z+\bar{z})/4(1-b)^2 - (z-\bar{z})^2/4(1+b)^2 = 1$$

which we recognize as an ellipse.

§ 10. If we wish to pass from a complex plane locus

$$z = \varphi(t)$$

to a real plane locus

$$f(x, y) = 0$$

we may do so as in the following illustration.

The equation

$$z = b/t + t$$

of article nine may be written

$$x + iy = b/(\cos\vartheta + i\sin\vartheta) + (\cos\vartheta + \sin\vartheta)$$

or, since t and i/t are conjugates

$$x + iy = b(\cos\vartheta - i\sin\vartheta) + (\cos\vartheta + i\sin\vartheta)$$
$$= (1+b)\cos\vartheta + i(1-b)\sin\vartheta$$

equating the real and imaginary parts

$$x = (1+b)\cos\vartheta\ ,\quad y = (1-b)\sin\vartheta$$

which gives an ellipse parametrically expressed, for the elimination of ϑ gives

$$x^2/(1+b)^2 + y^2/(1-b)^2 = 1$$

§ 11. In what precedes we have seen that when a curve in the real plane can be expressed parametrically we may pass to an analogous parametric expression of a curve in the complex plane. When the eliminations are practicable we can arrive at an equation

$$f(z, \bar{z}) = 0$$

in the complex plane, which corresponds in a way to the equation

$$f(x, y) = 0$$

in the real plane.

We have illustrated the way in which in special cases we may pass from the one to the other.

This opens up the field for an analytical geometry of the complex plane whose coördinates are z and $\bar{z}$, corresponding to the coördinates x and y of Des Cartes. In the foregoing we have investigated the forms for this new geometry which the well known curves: the right line, the circle, the ellipse, and the hyperbola take. Other plane curves might have been chosen and their equations got in a very similar manner.

§ 12. These principles considered here have an application in the theory of rolling curves. If we suppose one complex plane to move upon another complex plane in a prescribed manner, the points of each plane trace certain path curves in the other plane. It is not the purpose of this article to go further into that subject than to say that in the study of these path curves the foregoing methods are of incalculable use.

Chapel Hill, N. C.

THE FISHERIES OF NORTH CAROLINA†

By Joseph Hyde Pratt.

A new era was started in the development of the fishing industries of the State of North Carolina when the General Assembly of the State passed, on March 4, 1915, "An act to establish a Fisheries Commission and to protect the fisheries of North Carolina."*

This law, which is State-wide, is considered by nearly all who have investigated it to be the most efficient and best fishery law that has been passed by any State. Honorable William C. Redfield, Secretary of Commerce, in an address before the annual meeting of the National Association of Fisheries Commissioners on April 18, 1916, at Wilmington, North Carolina, said:

"I have taken no little pride, gentlemen of North Carolina, in pointing out personally to the Governors of other States and to the legislators of other States the progressive and effective law that exists here—a good law which has put the State of North Carolina in advance of others to its own good and to its great honor. I know that it has had a marked effect upon opinion elsewhere; that it has put this State of North Carolina in a position of prestige and dignity and self-respect and of vision for the future, and of common sense as regards the children that are to come, which has made it honorable in the sisterhood of States in this country. The State of North Carolina has led the way in this respect, and others have shown it the flattery of imitation."

It is believed that this law will enable the State to build up its fishing industry to a point where it can be compared favorably with a similar industry in any other State.

The passage of this law was brought about only by a campaign of education throughout the whole State, in which the people of the western and central portions of the State were informed as to the value of the fisheries, what they should mean to the State, and that they belong just as much to the people of the west as to those of the east. Many subjects appertaining to the fisheries of the State were discussed at various meetings in different parts of the State, and

*Public Laws of North Carolina, chapter 84, Session 1915.

†Paper read before meeting of American Fisheries Society, October 16, 1916.

pamphlets and newspaper sketches were printed upon these same subjects. Among the most startling points that were brought to the attention of the people regarding the fisheries were:

1. That North Carolina instead of being first in the output of her fisheries as is warranted by the abundance of her inland waters, which are peculiarly adapted for the maintenance of commercial fisheries, now holds eleventh place among the Atlantic and Gulf States.

2. That the ascendancy of these other States, particularly Virginia, Maryland, Connecticut, and Louisiana, has been obtained entirely through the enforcement of such regulations as would allow a reasonable catch from their fisheries and would preserve a sufficient part of the fish, so that the supply of each succeeding year would steadily increase instead of diminish.

3. That the decrease in the North Carolina fisheries is undoubtedly due to very heavy fishing of all kinds of apparatus, and the violation of the laws that have been passed to regulate fishing. This applies to both fin fish and shell fish.

4. That the most noticeable decrease in North Carolina fin fish has been among her more valuable fish, such as shad and herring.

5. That the oyster industry of North Carolina was at such a low ebb that it was hardly considered in the discussion of the oyster industry of this country.

6. That instead of the fish industry being worth from $7,000,000 to $8,000,000 per year, it is worth less than $3,000,000 per year.

7. That instead of North Carolina supplying her home demand of fish and oysters she is obliged at the present time to obtain a considerable proportion of them from other States.

8. That the fisheries of North Carolina belong to the whole State, and that the citizens of the State at large should be interested in their preservation and perpetuation.

The people, when they realized the condition of the fisheries and that they do belong to the State as a whole, took up seriously the question of how to protect and conserve this valuable asset of the State. As this was largely a question of legislation, it was pointed out:

First, that the legislation must provide for an impartial, uniform and efficient enforcement throughout all sections of the State, in the interest of all the people of the State, and not to the temporary interest of the fishermen.

Second, that the enactment of rules and regulations governing the fisheries must be such that they will give the greatest liberty to the fishermen consistent with the development and conservation of the fish industry.

Third, that the closest and most cordial coöperation should exist between the State commission and the Federal bureaus, particularly in the planting of fish and oysters.

Fourth, that in the administration of the laws and regulations governing the utilization of the fisheries a great deal of consideration must be given to the opinions and supposed rights of the fishermen, but that when the commission had, after due deliberation, passed certain regulations, these must be enforced impartially.

On account of the varied conditions that exist in all fishing localities there must be considerable elasticity in the law. The commission should have the power to regulate. The recently passed North Carolina laws are superior to those of other States in this question of elasticity. In support of this I would quote section 21 of the law, which is as follows:

"Sec. 21. The Fisheries Commission Board is hereby authorized to regulate, prohibit, or restrict, in time, place, character, and dimensions, the use of nets, appliances, apparatus or means employed in taking or killing fish; to regulate the seasons at which the various species of fish may be taken in the several waters of the State and to prescribe the minimum size of fish which may be taken in the said waters of the State; and such regulations, prohibitions, restrictions, and prescriptions, after due publication, shall be of equal force and effect with the provisions of this act; and any person violating the provisions of this section shall be guilty of a misdemeanor, and upon conviction shall be fined or imprisoned at the discretion of the court: Provided, however, that if a petition signed by five or more voters of the district or community which will be affected by the proposed change is filed with the Fisheries Commission Board through the Fisheries Commissioner, assistant commissioners, or inspectors, asking that they have a hearing before any proposed change in the territory, size of mesh, length of net, or time of fishing shall go into effect, petitioning that they be heard regarding said change, the Fisheries Commission Board shall in that event designate by advertise-

ment for a period of thirty days at the courthouse and three other public places in the county affected, and also by publication in a newspaper of the county, if such is published in said county, for two consecutive weeks, the place at which said board shall meet and hear argument for and against said changes, and may ratify, rescind, or alter this previous order of change as may seem just in the premises; and, Provided further, that in making regulations the Fisheries Commission Board shall give due weight and consideration to all factors which will affect the value of the present investment in the fisheries, and that no changes in the existing laws which, if they should go into effect immediately, would tend to cause fishermen to lose their property shall go into effect until twelve months from the date that the change has been made by the Fisheries Commission Board."

While the North Carolina law has only been in operation a little over a year, yet we are beginning to realize that it was a very valuable piece of constructive legislation that the General Assembly of 1915 passed, and that splendid results are to be obtained under it. While it does delegate to a central body the control of the fisheries of the State, it is, in my judgment, the only way by which our fisheries can be conserved and increased. Previous local control has nearly wiped out the sturgeon industry of North Carolina and other States; it has greatly decreased the mullet industry by reason of the catching of under-sized mullets; was rapidly depleting the striped bass and black bass fisheries, and it has nearly destroyed the oyster industry in this State and in others. On the other hand, where there has been a central control of fisheries, there has been a general restoration of certain fisheries that had been nearly depleted.

In 1907 North Carolina, according to Dr. Hugh M. Smith,* was far advanced in all phases of the fisheries among the South Atlantic States, and the State exceeded all the others combined as regards the number engaged in fishing, the amount of capital invested and the quantity and value of the annual yield. This is the prestige that North Carolina formerly had, and we believe that the operation of the present law will bring this back to her. There are but few other States that have as large a population so entirely dependent on the water for a livelihood as North Carolina.

The fish fauna of North Carolina is very rich in both species and individuals, and this is due to its great variety of topography and its

*North Carolina Geological and Economic Survey, Volume II, page 407; 1907.

large shallow sounds along the coast. It is stated by Dr. Hugh M. Smith, U. S. Commissioner of Fisheries,* that among the prominent features of the fish fauna are:

(*a*) The abundance of certain anadromous fishes, whose numbers are scarcely surpassed in any other waters, the chief of these being the shad, the alewives, and the striped bass.

(*b*) The variety and abundance of suckers, minnows, and sunfishes in the fresh waters generally, and of darters in the headwaters of the streams on both sides of the Alleghanies.

(*c*) The occurrence in the sounds and along the outer shores of immense schools of mullet, squeteague, menhaden, blue-fish, croaker, spot, pig-fish, pin-fish, and other food fishes.

(*d*) The extension to the North Carolina coast of many species which are characteristic of the West Indies or Florida.

(*e*) A few species of the Atlantic coast reach their southern limit in North Carolina (such as the cod and tautog), or do not occur in noteworthy numbers further South (such as the white perch and striped bass).

Of the 352 species of fish recorded from North Carolina about 95 at present have commercial value. To these would be added oysters, clams, mollusks, scallops, crabs, shrimps, turtles and frogs, which would represent the fisheries of the State.

North Carolina has been noted particularly for its production of black bass, shad, alewife, hickory shad, striped bass, white perch, eel, sturgeon, mullet, squeteague, croaker, spot, Spanish mackerel, and menhaden.

There is given below a list of the commercial fishes, together with localities from which they are obtained:

STURGEON. *Acipenser oxrhynchus.*

This species has been almost exterminated in the waters of North Carolina, where formerly it was very abundant. It is probable that by radical measures to prevent further diminution in the supply of this fish it can be restored to something like its original abundance. Dare County now produces the greater bulk of the sturgeon placed on the market from this State.

*North Carolina Geological and Economic Survey, Volume II, page 1; 1907.

GAR PIKE. *Lepisosteus Osseus.*

This species is also known in North Carolina as long-nosed gar and bill-fish, and is one of the common fish in Albemarle Sound and Neuse River. It has been put on the market to a considerable extent as a food fish, and there has been some demand for the skin to be used in covering boxes, sword hilts, etc. As the meat of this fish is well-flavored and wholesome, there is no reason why it should not be used more generally as a food fish.

SEA CAT-FISH. *Galeichthys milberti.*

This cat-fish frequents the beaches, sounds and bays and is the most abundant of the salt water cat-fishes, and is put on the market to a limited extent.

SPOTTED CAT-FISH. *Ictalrus punctatus.*

This cat-fish is reported as abundant in the French Broad River in Madison County, where it is used as a food fish, and is known locally as blue-cat.

WHITE CAT-FISH. *Ameiurus Catus.*

This is one of the best of the cat-fishes, and is marketed to some extent in North Carolina. It is especially abundant in Albemarle Sound and tributaries, and also occurs less abundantly in the Neuse and Yadkin rivers.

YELLOW CAT-FISH; Common Bullhead. *Ameiurus Nebulosus.*

This cat-fish, which is the common bullhead, occurs abundantly in the western end of Albemarle Sound and in Pasquotank and Roanoke rivers. While it is marketed to some extent, it is not considered of any large value as a food fish.

BROWN CAT-FISH; Mud cat-fish. *Ameiurus Platycephalus.*

This cat-fish is found abundantly in branches of Haw River in Guilford County; in the Little Yadkin River, Rowan County; in Catawba River, McDowell County; St. Johns River, Burke County. Locally it is used largely for food, but very few are put on the market.

YELLOW CAT-FISH. *Leptops Olivaris* (Rafinesque).

Only in the waters of the French Broad River and its tributary, the Swannanoa River, which are in the Mississippi basin, has this yellow cat-fish been found. It occurs in these streams in some quantity, and locally is a food fish of some importance.

WHITE SUCKER; Sand Sucker; Common Sucker. *Catostomus commersonii.*

This fish is commonly found in the Catawba River in McDowell County, the French Broad and Swannanoa rivers, Buncombe County. It has also been reported from the Yadkin and Neuse rivers. In the French Broad section it is known as sand sucker. In these sections it is considered an important food fish.

RED-HORSE; Shiner; White Mullet. *Moxostoma Papillosum.*

This is one of the commonest suckers found in North Carolina, and has been reported from the Dismal Swamp to the Cape Fear River, and thence to Georgia. It is common in the Tar River, Edgecombe County; Neuse River, Wake County; Little River, Wayne County; Haw River, Guilford County; Catawba River, Burke County; and Yadkin River, Yadkin and Rowan counties. Locally it is valued highly as a food fish.

WHITE MULLET. *Moxostoma Album.*

This sucker occurs very abundantly in the Catawba River and is highly valued as an article of food. In size this species is one of the largest, reaching four pounds and over, and is called by the people along the Catawba River white mullet.

SUCKER. *Moxostoma Thalassinum.*

This species is reported by Cope to have been very abundant in the Yadkin River and used locally for food.

RED-HORSE; White Sucker. *Moxostoma Aureolum.*

In North Carolina this sucker only occurs in streams tributary to the Ohio, which are all west of the Blue Ridge. It is found principally in the French Broad River and Spring Creek, one of its tribu-

taries, Madison County. It is used locally as a food fish in that section, where it is known as the white sucker. Fish of this species have been reported to have been caught that weighed twelve pounds.

RED-HORSE. *Moxostoma Robustum.*

This species has only been recorded by Cope, who reported its occurrence in the Yadkin River, and that it was highly valued as a food fish by the people living along the river.

RED-HORSE; Golden Mullet; Golden-finned Mullet. *Moxostoma Crassilabre.*

This species is abundant in the Albemarle region, and the larger fish have considerable market value. At Edenton and Elizabeth City the trade name for this fish is golden mullet and golden-finned mullet. At Plymouth it is on the market as red-horse.

RED-HORSE. *Placopharynx Duquesnii.*

This sucker is the common "red-horse" of the rivers in the western part of the State, and is used as a food fish.

CHOBY; Shiner; Silvery minnow; Smelt. *Hybognathus Nuchalis.*

This species is found very abundant in Pasquotank and Roanoke rivers and in Albemarle Sound near Edenton. It is caught and utilized to some extent for a food fish.

HORNED DACE; Dace; Chub. *Semotilus Atromaculatus.*

This species is found chiefly in brooks and is widely distributed in the State, being known in the French Broad, Catawba, Yadkin, Deep, Neuse, Tar, Cape Fear, and Roanoke rivers and their tributaries. It is a fish of fair size, some weighing as much as four pounds, and although only a fair food fish, it is used to considerable extent locally.

ROACH; Shiner; Shad Roach; Golden Shiner. *Notemigonus Crysoleucas.*

This minnow is very common in all parts of North Carolina east of the mountains, and is found in still and sluggish waters, particularly in the basins of the Catawba, Yadkin, Neuse, Tar and Cape

Fear rivers. It is also very abundant in the Albemarle region, and is caught during the shad season in large numbers in pound nets and seines. It is used for food, but principally for home consumption.

CARP; German Carp; Asiatic Carp. *Cyprinus Carpio.*

The carp was introduced in North Carolina in 1879 and now it is well known in all parts of the State, but is most plentiful in the warmer and more sluggish lowland waters in the eastern part of the State. While the production of this fish is small, it is one of the commercial fishes, and is put on the market from a dozen or more counties in eastern North Carolina.

EEL; Common Eel; Fresh Water Eel. *Anguilla Chrisypa* (Rafinesque).

This common eel occurs as a migrant in all the streams of North Carolina east of the Blue Ridge, but is only fished for commercially in certain sections in the eastern part of the State, as in the vicinity of Beaufort, Carteret County; New Bern, Craven County; Oriental, Pamlico County.

CONGER EEL; Sea Eel; Ocean Eel. *Leptocephalus Conger.*

This eel occurs somewhat abundantly in the harbor about Beaufort, and in the Newport and North rivers. It has also been found in the salt water sounds. It reaches a very large size, and is an excellent food fish. This fishery is capable of considerable development.

TARPON; Silver Fish; King Fish. *Tarpon Atlanticus.*

Each season the tarpon visits the North Carolina coast and enters the sounds as far north as Croatan Sound.

GIZZARD SHAD; Mud Shad; Nanny Shad. *Dorosoma Cepedianum.*

This species is present in the larger coastal waters of North Carolina throughout the year, and is usually abundant in the sounds and streams at the time these shad are passing from salt water to fresh water. Although the flesh of this fish is not of specially good quality, yet there is a market for a certain amount of it, particularly in winter.

HICKORY SHAD; Hick; Jack; Ship Jack. *Pomolobus Mediocris.*

This species is common in the coast waters and rivers of North Carolina, and in the winter it is caught in large numbers in Pamlico and other salt water sounds. In late winter or early spring it ascends the streams to spawn about the same time that the branch herring are seeking fresh water. Although a much inferior fish to the common shad, it brings a fair price on the market and there is some considerable demand for it.

BRANCH HERRING. Alewife; Branch Alewife; Goggle-eye. *Pomolobus Pseudoharengus.*

The alewives are one of the most abundant food fishes inhabiting the rivers of eastern North Carolina, and this State has been the leading alewife State in the country. They occur most abundantly in Albemarle, Croatan and Pamlico sounds and Neuse River. While many of these fish are put on the market fresh, the principal trade is in the salted fish.

GLUT HERRING; Herring; School Herring; Blue Back; May Herring. *Pomolobus Aestivalis.*

This herring comes later than the branch herring and usually appears about the middle of the shad season, but spawns a shorter distance from the sea.

SHAD; White Shad. *Alosa Sapidissima.*

The shad has been the leading commercial fish in North Carolina, and extensive fishing is carried on for the shad in the Cape Fear, Neuse, Pamlico, Tar, Roanoke, Chowan, Pasquotank, and Perquimans rivers, and in Albemarle, Croatan, and Pamlico sounds. At one time the shad fishery of North Carolina exceeded that of any other State, but owing, however, to excessive fishing, this fishery has declined to a very marked degree. The industry, however, has begun to feel the effect of the protective legislation that was passed, and it is expected that this fishery will soon be at high tide again.

HAIRY-BACK; Thread Herring. *Opisthonema Oglinum.*

This fish sometimes is found in considerable quantity in Beaufort harbor. It has little or no food value, but has been utilized at some of the fertilizer factories, being taken in hauling for menhaden.

MENHADEN; Oldwife; Alewife; Fat Back Shad. *Brevoortia Tyrannus.*

This is one of the most valuable of the North Carolina fishes, although not used at the present time to any large extent as a food fish. It is caught chiefly for conversion into oil and fertilizer. The principal plants are located in the vicinity of Beaufort, Carteret County; and in the Cape Fear River, Brunswick County.

SMELT; Bait; Anchovy; Striped Anchovy. *Anchovia Brownii.*

This fish is very common in the Beaufort region, Carteret County. While at the present time but little use is made of this fish as a source of food, they do exist in sufficient abundance to support a canning industry. If carefully preserved in oil similar to sardines, the fish ought to meet with a good sale.

BROOK TROUT; Speckled Trout; Mountain Trout. *Salvelinus Fontinalis.*

This trout is more or less abundant in nearly all of the streams of the mountain region of the State, which afford excellent fishing. The trout streams represent one of the more valuable resources of the Southern Appalachian region, and the State realizes the need of keeping the streams well stocked with trout and protecting them in the interest of the anglers.

RAINBOW TROUT; California Trout. *Salmo Irideus.*

This trout is not native to North Carolina, but was introduced into various streams of the State as early as 1880. While it is not equal to the brook trout as a food or game fish, yet it is better adapted to warmer and more sluggish waters than the brook trout, and to the changed conditions in western North Carolina, due to cutting of timber, etc.

PIKE; Red-finned Pike, Jack, Pickerel. *Esox Americanus.*

This pickerel is found in many of the streams, swamps and lakes of North Carolina. It is caught and used to some extent as a food fish.

CHAIN PICKEREL; Pike; Red-finned Pike; Black Pike; Duck-billed Pike; Jack; Pickerel. *Esox Reticulatus.*

This species is common in the lower courses of the eastern rivers of North Carolina. It is found most abundantly about Albemarle Sound, and it is from this section that the greatest quantity of this fish is marketed.

OHIO MUSKALLUNGE; Jack. *Esox Ohiensis.*

This species was recorded by Dr. Jordan from the French Broad River near Asheville, where it was reported to be one of the food fishes of that section, being known locally as "jack."

GAR-FISH; Bill-fish; Doctor-fish. *Tylosurus Marinus.*

This fish is common on the North Carolina coast, and during the spring it enters the sounds seeking fresh water. It is caught to some extent by the fishermen of Albemarle Sound, but is utilized only to a limited extent as a food fish. It is a fish, however, that should be more generally eaten, as its flesh is very palatable.

FLYING FISH. *Cypselurus Speculiger.*

This fish inhabits the open seas, and has occasionally been seen at Beaufort. It is a very superior food fish and may become one of the commercial fishes of the State.

SILVERSIDE; Sardine; Smelt. *Menidia Menidia.*

This species is common on the North Carolina coast, and has been taken at Beaufort harbor in midwinter, indicating that it is a permanent resident. It is a palatable fish, and is large enough to warrant its being used as a food fish. At the present time little or no use is made of the fish for this purpose.

STRIPED MULLET; Mullet; Jumping Mullet. *Mugil Cephalus.*

Of all the salt water fish of North Carolina this is the most abundant and important, and this State has ranked second in the extent of the mullet fishery. There has been a practice of marketing undersized mullets and using the smaller ones for fertilizer purposes. This will tend to cut down the supply and may lead to the extermination of this valuable fish. The new Fisheries Commission has passed regulations prohibiting this practice.

Mullets are caught in every county bordering on the salt water, but the bulk of the yield comes from Brunswick, New Hanover, Pender, Onslow, Carteret, Pamlico, and Dare counties. The largest recorded North Carolina mullet weighed ten pounds.

WHITE MULLET; Silverside Mullet; Blue-back Mullet; Mullet. *Mugil Curema.*

This mullet is less numerous than the striped mullet, with which it is associated. It is usually not distinguished from the striped mullet by the local fishermen, and the two are marketed together.

LITTLE TUNNY; Bonito; Bolter. *Gymnosardo Alleterata.*

This species is very irregular in its appearance along the North Carolina coast, but has been caught in the ocean off Nags Head. While at the present time the fish is not regarded with any particular favor as food in North Carolina, yet it is one of the fish that may in time become a commercial food fish of considerable importance.

TUNNY; Horse Mackerel; Albacore. *Thunnus Thynnus.*

This fish, which frequents the North Carolina coast, has not been caught to any large extent, and although a first-class food fish, it is not regarded as such in this country. It is a large fish, and probably could be caught in quantity if a market could be provided for it, and thus make an important fishery in this country as it does in Southern Europe.

BONITO. *Sarda Sarda.*

This fish is caught to a limited extent in the waters of Carteret County, but no particular attempt is made to catch this fish in large

quantity as at the present time it does not rank high as a food fish on our markets. It is, however, an excellent food fish, but unless bled immediately after capture, it is apt to deteriorate. This is probably one of the reasons why the fish has not been more generally considered a good food fish.

SPANISH MACKEREL. *Scomberomorus Maculatus.*

The Spanish mackerel is the highest priced fish caught in North Carolina waters and is caught principally by the fisheries of Carteret, Pamlico, Hyde, and Dare counties.

KING-FISH; Cero; King Cero; Spotted Cero; Spotted Mackerel. *Scomberomorus Regalis.*

This king-fish occurs regularly in summer in Beaufort harbor, and is caught and used as a food fish. The fishermen do not make any distinction between this and the Spanish mackerel and cero.

CERO; King-fish. *Scomberomorus Cavalla.*

This species has been caught to some extent by the seine fisheries in Carteret County. On account of the fact that it does not have good keeping qualities, it is not regarded as a specially good fish to market fresh, but as a salted fish it is very good.

AMBER-FISH; Yellow-tail. *Seriola Lalandi.*

While but very little attempt is made at the present time to capture this amber-fish, it does occur off the North Carolina coast, and could be found in quantity if properly sought after. Some years ago it was caught off the beaches at Nags Head, Dare County. It has value as a food fish and could probably support a fishery.

CAVALLY; Olbacore; Albacore; Horse Mackerel. *Caranx Hippos.*

This species occurs off the North Carolina coast and was formerly caught in considerable quantities at Beaufort, but in recent years it has not been as abundant.

MOON-FISH; Sun-fish; Horse-fish. *Vomer Septipinnis.*

This fish occurs off the outer beach near Beaufort in the fall, and is put on the market to a limited extent.

GAFF-TOPSAIL POMPANO. *Trachinotus Glausus.*

This pompano has been caught to a limited extent, but does not rank high as a food fish, and but little attention has been paid to it. The principal catch has been at or near Beaufort.

POMPANO; Permit. *Trachinotus Goodei.*

This pompano has been captured to some extent off the shores of Hyde, Carteret, and New Hanover counties, but very little use however is made of it as a food fish.

POMPANO; Sun-fish. *Trachinotus Carolinus.*

This is one of the best of our salt water food fishes, and has been caught and put on the market from Carteret, Beaufort, and Pamlico counties. This fishery is capable of considerable development.

BLUE-FISH; Tailor; Green-fish; Skip-jack; Snapping Mackerel. *Pomatomus Saltatrix.*

This is one of the more important salt water fishes of the State. The principal fishing for the blue-fish is in Carteret, Dare, Beaufort, Craven, Hyde, New Hanover, Onslow, and Pamlico counties.

CRAB-EATER; Cabio; Sargeant-fish. *Rachycentron Canadus.*

This species has been caught to a limited extent off the North Carolina coast from Cape Lookout south, and a market has been found for them in many sections of the State. In some instances this fish has been sold as cero.

HARVEST FISH; Star Fish; Star. *Peprilus Alepidotus.*

In the vicinity of Roanoke Island, in Croatan and Pamlico sounds, and in Beaufort harbor, this fish is caught in considerable numbers and is considered an excellent food fish.

BUTTER-FISH; Butter-perch; Dollar-fish; Harvest-fish. *Poronotus Triacanthus.*

This fish is caught in considerable quantity in Beaufort harbor, Pamlico Sound, and at Cape Lookout. It is considered an excellent pan fish, and is marketed in some quantity in this State.

CALICO BASS; Strawberry Bass; Crappy; Speckled Perch; White Perch. *Pomoxis Sparoides.*

This fish is common in Albemarle Sound and tributaries, in Tar and Neuse rivers and other streams of the Coastal Plain region. It is also found to some extent in certain of the rivers of the Piedmont region. This fish ranks high as a game fish, and is also considered a good food fish.

FLYER; Mill-pond Perch; Sun-fish. *Centrarchus Macropterus.*

This species, although small in size, is used locally at Plymouth and other places as a food fish, and is caught to some considerable extent in the Roanoke, Neuse, and Tar rivers.

ROCK-BASS; Red-eye. *Ambloplites Rupestris.*

This bass is confined in North Carolina to the French Broad River and its tributaries. As a game fish this ranks high, and it is also a good food fish.

GOGGLE-EYE; Chub; Mud Chub; Red-eyed Bream; Warmouth; Red-eye. *Chaenobryttus Gulosus.*

This species is reported as common in all the streams east of the Alleghany Mountains, in Albemarle Sound and tributaries, and in the Cape Fear River. It is in the Wilmington markets practically throughout the year, although it is not caught in any great abundance.

LONG-EARED SUN-FISH; Red-belly; Robin; Yellow-belly. *Lepomis Auritus.*

This species has been found in some abundance in the Catawba, Yadkin, Neuse and Cape Fear rivers and Albemarle Sound. It is caught to a limited extent and marketed.

BLUE-JOE; Blue Perch; Blue-gill; Blue Sun-fish. *Lepomis Incisor.*

This fish is common in the creeks near Edenton and in Roanoke River at Weldon, and is sold in the local markets. This is the largest and finest of the sun-fishes and stands high as a game and food fish.

SAND PERCH; Robin; Robin Perch; Pumpkin-seed. *Lepomis Gibbosus.*

This is one of the commonest fishes and is very abundant in ponds and streams. It is caught in some quantity in Washington, Currituck, Camden, Dare, and other counties in the eastern part of the State, and put regularly on the market.

SMALL-MOUTHED BLACK BASS. *Micropterus Dolomieu.*

This species is known to occur commonly in the Neuse River near Raleigh; Little River at Goldsboro; Swannanoa River near Asheville; and Spring Creek near Hot Springs. It is one of the best game fish, and it is also a good food fish.

LARGE-MOUTHED BLACK BASS; Welshman. *Micropterus Salmoides.*

This bass is found to a limited extent in the mountain region of North Carolina, but it is a fish of the Piedmont Plateau and Coastal Plain regions. It is especially abundant in Currituck Sound and in tributaries of Albemarle Sound. The large-mouthed black bass industry has been larger in North Carolina than in any other State, and Currituck Sound produces about three-fourths of the total yield.

WALL-EYED PIKE; Pike Perch; California Salmon; River Trout. *Stizostedion Vitreum.*

The pike perch fishery has not been developed to any large extent in North Carolina, although its range covers a large part of the State, having been found in the French Broad River and in many rivers of the Coastal Plain region. This species ranks high as a game fish, and is also considered a splendid food fish. If this fish was cultivated, it could probably be made an important industry in certain parts of the State.

RED-FIN; Yellow Perch; Englishman; Raccoon Perch. *Perca Flavescens.*

The yellow perch occurs rather abundantly in the fresh water streams and sounds and lakes of eastern North Carolina. It is a

good food fish and has been put on the market to some extent. It is also caught in large quantities by anglers. In North Carolina the largest catch comes from Currituck County.

STRIPED BASS; Rock-fish; Rock. *Roccus Linaetus.*

This is one of the largest and best of the fresh water fishes, and is found in many of the fresh water reams of eastern North Carolina, being especially abundant in the Albemarle region. This State leads nearly all the others in the quantity of striped bass caught, the most extensive catch coming from Dare County. The other counties marketing large quantities are Currituck, Chowan, Bertie, Martin, Halifax, Washington, Beaufort, and Craven.

PERCH; White Perch; Silver Perch. *Morone Americana.*

This fish occurs in the fresh, brackish, and salt waters of eastern North Carolina, being especially abundant in the Albemarle Sound region. In Currituck Sound it exists in greater abundance than any other commercial species. It is also found in quantity in New, Neuse, and Cape Fear rivers. Commercially it is more valuable than the yellow perch.

SEA BASS; Black Fish; Bass. *Centropristes Striatus.*

This sea bass, which in North Carolina is called black-fish and bass, occurs in abundance off the coast of North Carolina, and is caught for market in various sections. This fishery should be increased to a considerable extent, and at a good profit. The greater portion of the catch of this fish is from Carteret and New Hanover counties.

RED SNAPPER. *Lutianus Blackfordi.*

This important food fish has not been found in any great abundance on the grounds lying off the coast of North Carolina, except in the extreme southeastern portion off Cape Fear, where certain banks are known as "snapper banks."

PIG-FISH; Hog-fish. *Orthopristis Chrysopterus.*

This fish is one of the commonest of the food fishes of the North Carolina coast, occurring as it does in all the sounds and salt water

estuaries as well as on the outlying banks. It is one of the leading food fishes of the State, and is caught most extensively in the Beaufort region, Carteret County; and Pamlico Sound, Hyde County; and on the coast of New Hanover County.

SNAPPER; Grunt. *Haemulon Plumieri.*

This species undoubtedly occurs regularly on the various banks lying off the North Carolina coast. It is caught in some quantity off the coast of New Hanover and Brunswick counties, and marketed in Wilmington, where it is known as "snapper." There is a good opportunity of developing this fishery to a much greater extent.

GRUNT; Tom-tate; Red-mouthed Grunt. *Bathystoma Rimator.*

This red-mouthed grunt, which is abundant at Charleston, South Carolina, should be common along the southern part of the North Carolina coast.

SCUP; Pin-fish. *Stenotomus Chrysops.*

This scup has not been caught in very large quantity on the North Carolina coast, and no distinction is made by the fishermen between this fish and the southern scup or porgy (*Stenotomus Aculeatus*).

SOUTHERN SCUP; Porgy; Long-spined Porgy. *Stenotomus Aculeatus.*

This species should be found at Cape Fear, Beaufort, and other points.

ROBIN; Sailor's Choice; Pin-fish. *Lagodon Rhomboides.*

This fish is exceedingly abundant at Beaufort, Cape Fear, and elsewhere on the North Carolina coast, where it is known as pin-fish and robin. It was formerly thrown away but is now becoming a commercial fish and is marketed in some quantity in this State, principally at Wilmington.

SHEEPSHEAD. *Archosargus Probatocephalus.*

This species occurs in all the bays and estuaries of the North Carolina coast, although nowhere is it found in very great abundance, Carteret, Dare, Beaufort, and Pamlico counties producing the greatest yield.

SQUETEAGUE; Trout; Weak-fish; Sea Trout; Gray Trout; Summer Trout. *Cynoscion Regalis.*

This species is abundant along the North Carolina coast, but not in as large numbers as the spotted trout, and, like it, is present almost throughout the year.

SPOTTED SQUETEAGUE; Speckled Trout; Sea Trout; Trout; Spotted Weak-fish; Southern Squeteague; Black Trout; Salmon Trout. *Cynoscion Nebulosus.*

This fish is very abundant in North Carolina, and from an economic standpoint is the principal member of the drum family.

YELLOW-TAIL; Perch; Silver Perch; White Perch; Yellow-finned Perch; Sand Perch. *Bairdiella Chrysura.*

The yellow-tail abounds in the North Carolina sounds, estuaries and salt waters generally from early spring to late fall. Although a small fish, it makes an excellent pan fish, comparable with the spot, and could be made of some considerable economic value.

SPOT. *Leiostomus Xanthurus.*

The spot is very abundant in the sounds and other coastal waters of North Carolina, and in certain seasons enters perfectly fresh waters. North Carolina spots find a ready market in Baltimore, Washington and other cities.

CROAKER; Crocus; Hard-head. *Micropogon Undulatus.*

This is another one of the common food fishes of the North Carolina coast, being found in nearly all the sounds, estuaries and inlets and on the outer shores. The croaker is caught along the entire coast and has become one of the very salable species.

DRUM; Red Drum; Red-fish; Spotted Bass; Channel Bass. *Sclaenops Ocellatus.*

The red drum is one of the larger and more valuable of the food fishes, but as a fishery it has not been developed to as great an extent as it should be. This fishery is most extensive in Carteret County, but the fish are also caught in the Cape Fear region and about Roanoke Island.

SEA MULLET; King-fish; Carolina Whiting; Round-head; Whiting; Sea-mink. *Menticirrhus Americanus.*

This fish is abundant about Roanoke Island, Pamlico Sound, around Cape Lookout, Beaufort harbor, and Cape Fear. This fish is of exceptionally good quality, and at times commands a fancy price.

KING-FISH; Sea Mullet; Sea-mink; Whiting. *Menticirrhus Saxatilis.*

This species is usually not distinguished by the North Carolina fishermen from the preceding species, *Menticirrhus Americanus.* This fish is especially esteemed in New York and New Jersey markets. It is probable that if the king-fish were separated from the sea mullet or Carolina whiting, it would bring a better and more constant price.

SURF WHITING; Sea Mullet; Whiting; Silver Whiting. *Menticirrhus Littoralis.*

This whiting is rather common at Beaufort during the summer, and is marketed with the two preceding species.

BLACK DRUM; Sea Drum. *Pogonias Cromis.*

The black drum is less abundant than the red drum in North Carolina, and nowhere near as valuable as a food fish. It is very seldom shipped, and the principal use of it as a food fish is made locally by some of the fishermen.

TAUTOG; Oyster-fish. *Tautoga Onitis.*

This fish is not very abundant in North Carolina, and while it does not support a special fishery, it is some years caught in considerable numbers, especially in the waters of Beaufort harbor.

PORGEE; Spade-fish; Moon-fish. *Chaetodipterus Faber.*

This species is found on the North Carolina coast only in summer. Its flesh is of excellent quality, and there is considerable demand for it in the New York and Washington markets. The bulk of the catch has come from Craven, Dare, and Pamlico counties.

SUN-FISH; Head-fish; Moon-fish; Mola. *Mola Mola.*

This sun-fish, which attains a weight of fifteen hundred pounds, may become of economic value if it is determined that glue may be made from the abundant subdermal elastic tissue.

COD. *Gadus Callarias.*

At the present time cod fishing is of little or no importance in this State, but this species is known to occur regularly on the North Carolina coast north of Cape Hatteras, and it is possible that a winter codfishery of some importance might be established on the northern part of the coast. According to Dr. Smith, the fish will be found in greatest abundance on the off-shore shoals, and could be caught easily with lines or gill nets.

THE FLOUNDERS. Family *Pleuronectidae.*

There are seven flounders that are known to occur in the North Carolina waters or on the adjacent ocean bottom, and this fishery has become of considerable increasing economic importance in the State. The bulk of the production comes from Beaufort, Carteret, Dare, Hyde, and Pamlico counties.

FLOUNDER; Summer Flounder; Mud Flounder; Sand Flounder; Plaice. *Paralichthys Dentatus.*

The summer flounder is one of the most valuable of the flat fishes. Although a salt water fish, it is often caught in fresh water streams far from salt water.

SOUTHERN FLOUNDER; Flounder. *Paralichthys Lethostigmus.*

This flat fish is similar in size and habits to the summer flounder, and is more common in the coast and salt waters of North Carolina. It regularly resorts to fresh waters, and, according to Dr. Smith, is the only local flounder with that habit. It is common in the western end of Albemarle Sound.

FLOUNDER. *Paralichthys Albiguttus.*

This flounder is common around Beaufort and Cape Lookout and usually is not distinguished by the fishermen or merchantmen from the other flounders.

While some of the fishes enumerated above are only produced to a limited extent in this State, yet all of them do represent a portion of the natural food supply of the State, and many of them offer opportunities for much larger developed fisheries. Owing to the scarcity of certain of the more desirable fish, some of those which formerly had been considered of little or no value as a food fish have been found to be very palatable, stand transportation well, and when put on the market find a comparatively ready sale, although sometimes at rather low prices.

If North Carolina will cater to the trade and take particular care in the packing of the fish for transportation, in refraining from trying to put undersized fish on the market and keeping the fish in their own class, so that a certain trade name will always mean a certain fish, there is no reason why the fin fisheries of the State should not be greatly increased both in production and value. One phase of the work of the Fisheries Commission is along this line, and they are trying to have all the fish product from this State go out as North Carolina fish. With the increased railroad facilities in eastern North Carolina, it is now possible for the fisheries to ship their products into all parts of the country in competition with any of the other Atlantic States.

More attention is being given to the development of new fishing grounds, particularly to those off-shore on the submerged banks and in the surface waters; also to a more thorough exploitation of the old fishing grounds. Another means of increasing the industry which the State, through its commission, has recognized and is trying to carry out, is to increase the abundance of fish through cultivation. Still another means of increasing the industry, and which to the author is one of the more important ones, is the utilization of certain fishes which are now considered of little or no value. The U. S. Bureau of Fisheries has demonstrated conclusively that by a systematic advertisement fish which are known to be palatable and are a good source of food can be made to become a very marketable fish. This is well illustrated in the tile-fish, which, through the efforts of the Federal Government, has become a commercial fish of considerable importance. This Bureau has also been successful in bringing

the sea-mussel on the market as an article of food. Now they are considering a well known member of the shark family as a food fish, and personally I can see no reason why this particular member of the shark family, which unfortunately is known as dog-fish, should not become a staple article of food, marketed in steaks similarly as the sword-fish. The suggested commercial name is gray-fish.

In speaking of the future of the fin fish industry in North Carolina, Dr. Hugh M. Smith stated:*

"The fisheries may be expected to deteriorate—

"(a) Through failure of the State to provide prompt and adequate protection to those fishes which begin to show a decrease in abundance. The history of the sturgeon is an unmistakable indication of what will eventually happen to the shad, alewives, striped bass, and other species unless ample provision is made for the survival of a sufficient percentage of the annual run until spawning has ensued.

"(b) Because of unnecessarily wasteful methods, such as the capture of larger quantities of food fishes than can be utilized or disposed of to advantage and the useless destruction of large numbers of fishes of no present market value but of prospective importance.

"(c) Owing to careless methods of packing and preserving the catch, and to failure to keep abreast of the progress of the times in matters affecting the shipment and sale of fish."

The State is already taking cognizance of Dr. Smith's warnings (*a*) and (*b*), by the passage of the Fisheries Commission bill, which provides legislation for the protection of the fishes of the State and machinery for enforcing the laws. Also the Commission has the authority to regulate methods of catching and disposal of fish, which will prevent the waste in warning (*b*). The question of methods of packing and preserving the catch is receiving serious consideration, and improvement is being made along this line.

Thus there is every reason to believe that the fisheries of North Carolina will not only be maintained for an indefinite period, but will show marked growth in production and value.

OYSTER INDUSTRY.

North Carolina at the present time not only does not hold first place in the country in the oyster industry, but, as has been stated

*North Carolina Geological and Economic Survey, Volume II, page 412; 1907.

by the Oyster Commissioner of Virginia,* "Maryland is far behind Virginia in the laws and methods of administration of its oyster industry, while North Carolina is hardly in the running." Since that time conditions have changed, and North Carolina now leads in laws and methods of administration, although not yet in production. If the present law can remain in force, it will not be many years before the oyster industry of North Carolina will be equal to that of any South Atlantic State.

In the case of the oyster, as with certain of the fin fish, it will be necessary for the Fisheries Commission to insist that the oysters caught and marketed in this State shall be put on the market as North Carolina products. The Pamlico and New River oysters are equal to those caught in any other State in this country, and if the beds producing these oysters are cultivated and protected and the oysters vigorously advertised, it will not be long before the Pamlico oyster and the New River oyster will be as widely known as the Lynnhaven and the Blue Point.

The oyster canning industry is also capable of very large development in this State, and the Fisheries Commission is already taking steps to obtain legislation which will prevent the North Carolina canned oyster from being shipped as Virginia stock.

A very satisfactory law regarding the cultivation of the oyster was passed by the General Assembly of North Carolina,† but very little was accomplished under this law until the passage of the Fisheries Commission bill in 1915. Now the cultivation of the oyster is beginning to receive more serious consideration.

When we stop to consider that Pamlico Sound is as large as Long Island Sound, where something over 80,000 acres are under cultivation, and something like half as large as Chesapeake Bay, where approximately 20,000 or more acres are held for cultivation, it will be realized that the possibilities for oyster culture in this State are very large. The State has already proved through experimental work that the cultivation of the oyster can be carried on profitably in this State.‡

*"Virginia Fishing Industry," Oystermen and Fishermen, April, 1911, page 9.

†Public Laws of North Carolina, Chapter 871, Session 1909.

‡See Bulletin 15, North Carolina Geological and Economic Survey, 1907, on Experiments in Oyster Culture in Pamlico Sound.

Oystering is carried on in ten counties—Dare, Hyde, Beaufort, Pamlico, Craven, Carteret, Onslow, Pender, New Hanover, Brunswick. The greatest number of oysters, however, are taken from Hyde, Beaufort, Dare, Carteret, and Onslow counties.

ROUND CLAMS (Quahogs). The clam industry has never become of great importance in this State, although there are certain sections where it is capable of being developed to a considerable extent. A few experiments have been made regarding the cultivation of the clam which were rather successful. At the present time what clams are produced come principally from Brunswick and Carteret counties. This industry is capable of very large development in this State.

SCALLOPS. Only very small quantities of scallops have been gathered and marketed in this State, and these were obtained in Carteret County. No particular investigation has been made in regard to this phase of the fishing industry of the State, but it is believed that it can be developed to a very much greater extent than it is at the present time.

CRABS. The principal crab that is caught in North Carolina is the common blue crab, and nearly the entire catch is sold in the soft-shell stage. Very few people realize that there is any crab industry in this State, for the reason that at present practically all of the crabs are shipped by Chrisfield, Maryland, packers, and usually go on the market as Maryland crabs. This industry is small but is capable of very large development, and if the plans of the Fisheries Commission can be carried out, it will be developed as a North Carolina crab industry. The crabs that are marketed are taken generally in Carteret County, although a good many are caught in Dare County around Roanoke Island. Although crabs are caught for local use in nearly all of the salt water counties, very few are put on the general market except from Carteret.

SHRIMP. The shrimp industry is confined to Brunswick, New Hanover, and Pender counties, the two former having the larger production. Little thus far has been done to develop this industry, but measures have been taken by the Commission to protect it and prevent its wasteful destruction.

REPTILIAN WATER RESOURCES. Of the reptilians there occur in North Carolina alligators, green and other sea turtles, diamond back

and other terrapins, and frogs. Of these the terrapin and frog are to be considered of commercial importance. A series of experiments were conducted in regard to the cultivation of the diamond-back terrapin, which proved successful,* and already one company has been organized and is carrying on the cultivation of the terrapin at Beaufort, North Carolina. The diamond-back terrapin is taken in small numbers about Roanoke Island and on the marshes of Beaufort harbor.

Frogs are hunted and marketed to a limited extent in Pasquotank and Camden counties.

The above will give some idea of the fishing resources of the State, which it is believed will in the near future be worth, instead of a few million, seven or eight million dollars per year to the State.

In closing I wish to say a word in regard to the cultivation of fishes in North Carolina, inasmuch as this State was one of the first to take up artificial propagation of fishes. I believe that the State can make no better expenditure of funds in connection with the fishing industry than in systematic fish culture, and I believe further that it is the duty of the State to establish and maintain several small hatcheries to assist in the replenishment of certain desirable fishes in our upland as well as lowland streams. This State has had the hearty coöperation of the Federal Government in the development of its fisheries, and the U. S. Bureau of Fisheries has maintained a shad hatchery at Edenton for a great many years.

With the passage of the Fisheries Commission Act, which should insure the enforcement of laws and the protection of the fish, there is still more reason for an increased number of hatcheries in this State, and greater coöperation of the State Commission with the U. S. Bureau of Fisheries. It is to be hoped that the two commissions will take up the artificial propagation of the sea mullet, spotted squeteague and other valuable salt water species, in addition to the cultivation of the brook trout, rainbow trout, small-mouthed black bass and spotted cat-fish for the mountainous regions, and the large-mouthed black bass, strawberry bass, and various sun-fishes for the lowland waters.

*Cultivation of the Diamond Back Terrapin, Bulletin 14, North Carolina Geological and Economic Survey, 1906.

SOME KNOWN CHANGES IN THE LAND VERTEBRATE FAUNA OF NORTH CAROLINA

By C. S. Brimley

This paper is an attempt to bring together in one place what data is in the possession of the author, relating to the changes undergone by the land vertebrate fauna of North Carolina, since the coming of the white man.

I. Mammals.

1. American Buffalo (*Bison bison* L.). "Originally ranged over much of western North Carolina, but exterminated about 1760." (Oberholser.)

2. American Elk (*Cervus canadensis* Erxl.). "Occurred in colonial times at least till about the year 1750." (Oberholser.)

3. Southern Beaver (*Castor canadensis carolinensis* Rhoads). Formerly more or less common throughout the state as evidenced by the frequent occurrence of the names "Beaver Creek" or "Beaver Dam Creek," but now nearly or quite extinct. Five specimens were collected for the State Museum in 1897 on the Dan River, near Danbury in Stokes County, and there is one in the museum which was collected near Weldon about 1884. In 1903, while collecting data for a list of North Carolina mammals, I received the following replies to my questions concerning beavers: "Not very common in Bertie County." (T. A. Smithwick.) "Very scarce, but a few" (in Buncombe County). (N. A. Fain.) "Rare; some few in Beaver Swamp in north Guilford and south Rockingham counties." (J. H. Armfield.) "Forsyth County, very few; some along Yadkin River." (K. E. Shore.) In 1905 Oberholser says of this species in western North Carolina: "Formerly occurred near Asheville; extinct in Pisgah Forest."

4. Roof Rat (*Mus alexandrinus* Geoff. St Hil.). Introduced from the Mediterranean region, probably during colonial times, and apparently till recently the common house rat of the State, at least in the interior. Disappeared from Raleigh about 1908 or 1909 and replaced by the brown rat. In the neighborhood of my own residence

the roof rats disappeared before I knew that there were any brown rats in Raleigh. Oberholser states that in the western part of the State it is apparently of rather recent introduction, and that specimens were taken in Pisgah Forest (Pink Beds) at 3,300 feet in August, 1904.

5. BROWN RAT, "WHARF RAT" (*Mus norvegicus* Erxl.). Known to have been common near Beaufort in 1871 (Coues), and to have occurred at New Bern in 1884 (H. H. Brimley). First taken at Raleigh in March, 1909, and became the common house rat of that locality within two years. We heard that it overran Kinston a few years previously.

6. GRAY WOLF (*Canis mexicanus nubilis* Say). Dr. Merriam in 1887 (Remarks on Fauna of Great Smoky Mountains) mentions the wolf as still occurring in our mountains, while Rhoads in 1895 (Mammals of Tennessee) mentions one as having been seen in 1883 near the Cloudland Hotel on the top of Roan Mountain. In 1903 I was informed that wolves still occurred sparingly in Graham, Cherokee, Buncombe, Caldwell, Yancey, and Watauga counties, and Dr. C. Hart Merriam wrote me about the same time that during one of his visits to Roan Mountain (in 1887 or 1892?) a den of wolves was discovered there and the young captured. Lastly, in May, 1912, while at Sunburst in Haywood County, I was informed by Mr. Eli Potter, woods superintendent of the lumber company operating in that region, that wolves were extinct in the mountains; that a band had committed depredations on stock some twenty-five years previously (about 1887), and that in consequence the people had joined together and killed out every one. Another man, a teamster, who was standing by at the time, agreed with him, and stated further that in the same year a litter had been raised near Highlands, but every one was killed. On the other hand, a few days before, another man, evidently only an ordinary mountaineer, had told me that wolves had been nearly exterminated, but were then slightly on the increase. Mr. Potter flatly contradicted this, saying no wolves were left in the mountains.

7. SOUTHERN WEASEL (*Putorius noveborabensis notius* Bangs). This species appears to be at least somewhat more common at Raleigh

than in former years, as from 1884 to 1907, during most of which period I was on the lookout for mammals, I only came across two specimens, while from 1908 to 1916 I have known of at least a dozen being taken, although not on the lookout for them.

8. PANTHER (*Felis cougar* Kerr). About 1900 my brother and myself were informed by Mr. Walton E. Stone that a panther had been killed near Rose Bay, in Hyde County, shortly before the Civil War; and in May, 1908, while at Lake Ellis in Craven County, I was told that one had been killed below New Bern about the same time or a little later. In both cases the animal was described as much larger than a wildcat, and as having a long tail. Recently my brother, H. H. Brimley, Curator of the State Museum, has informed me that he was told by a Mr. Vyne of North Wilkesboro that the latter had killed one in the Lake Ellis region somewhere about 1885. Oberholser states in 1905 that "The skin of one said to have been killed by a Mr. Drew near Highlands, about 1886, was recently seen there by Mr. R. G. Murdoch."

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Among other mammals, the deer, bear, and wildcat, once distributed throughout the State, are now confined to the mountains of the western section and the swamps of the coastal plain, in which latter section deer are still quite plentiful in many places. The coon or raccoon is getting scarce in the central portion of the State and its distribution in the near future will probably be similar to that of the three others just mentioned.

II. BIRDS.

1. COMMON TERN (*Sterna hirundo* Linn.). Coues in 1871 calls this bird very common during the migrations, near Beaufort, but in the eighties, and in fact until the Audubon Society of the State was organized, it was very greatly diminished in numbers by the persecutions of the plume hunters. Under the protection accorded this species and others by the "Audubon Law," it has of late years been increasing again, so much so, indeed, that in June, 1909, Phillipp called it "very abundant" in Pamlico Sound.

2. LEAST TERN (*Sterna antillarum* Lesson). This species was

more abundant than the common tern in Coues' day, suffered more from the plume hunters, and has less completely regained its former numbers.

3. EGRET (*Herodias egretta* Gmelin). Coues in 1871 found this species only moderately common near Beaufort in late summer, and it still occurs and even breeds (in company with the next in one place in the coastal region), though almost exterminated by the persecutions of the plume hunters.

4. SNOWY EGRET (*Egretta candidissima* Gmelin). Coues in 1871 mentions it as occurring "most often in flocks of considerable size"; now, however, it is but seldom met with, though still breeding at one place in eastern North Carolina.

5. MARBLED GODWIT (*Limosa fedoa* L.). Abundant in Coues' day, now apparently much reduced in numbers, though in 1901 Bishop calls it a common migrant on Pea Island in May.

6. LONG-BILLED CURLEW (*Numenius americanus* Bechstein). In Coues' time it was "resident, abundant during the migrations"; now it seems to have totally disappeared from our coast. The last one known to have been taken was killed off Shackleford's Banks in 1885; but Pearson records seeing the species in May, 1898, near Cape Hatteras.

7. GOLDEN PLOVER (*Charadrius dominicus* Muller). Coues calls this species common during the migrations near Beaufort; now it seems to have entirely disappeared from our coast. Our last North Carolina record is one taken near Raleigh in the fall, about 1884, by W. S. Primrose.

8. PASSENGER PIGEON (*Ectopistes migratorius* L.). Once extremely abundant, now extinct. John Lawson in his History of North Carolina, published in 1714 in London, says of these birds in the Cape Fear region: "I saw such prodigious flocks of these birds . . . that they had broke down the limbs of a great many large trees . . . whereon they had chanced to sit and roost; . . . These Pigeons about sunrise when we were preparing to march on our journey would fly by us in such vast flocks that they would be near a quarter of an hour before they had all passed, . . . and so successively one after another for the greater part of the morning."

Dr. K. P. Battle, Jr., of Raleigh, has informed me that about 1875, while a student at Bingham School in Alamance County, he saw a flock of these birds that was about a mile wide, and that in 1878 he killed one out of a flock of three at Chapel Hill. H. H. Brimley saw three at Raleigh between 1881 and 1891, the last being on April 18, 1891; but the last known record for North Carolina is that of a female killed by the late J. S. Cairns near Asheville, on October 20, 1894.

9. CAROLINA PARROQUET (*Conurus carolinensis* L.). Now extinct in the State. Occurred on Roanoke Island in 1586, according to Thomas Heriot, who includes "parrots" in a list of birds of the island seen in that year, while Colonel William Byrd of Westover, Va., in 1729, states that parroquets visit North Carolina, but only during the warm season.

10. NORTHERN RAVEN (*Corvus corax principalis* Ridgway). (1) Coastal Region: In 1884 a mounted specimen, said to have been taken below New Bern, was in the possession of a local taxidermist of that place. On June 4 and 8, 1892, the species was seen by H. H. Brimley near Beaufort. Lastly in May, 1908, while at Lake Ellis, Craven County, I was told by several persons that they had formerly occurred, but that none had been seen for a number of years. (2) Mountain Region: Apparently still distributed through the mountains, our latest data being as follows: Roan Mountain, A pair apparently resident here in early June, 1911 (Bruner and Feild); Grandfather Mountain, Two or three seen every day during last week of June, 1911 (Bruner and Feild); Highlands, Five seen contending over a carcas on both May 13 and May 14, 1912, by Mr. S. C. Clapp, State nursery inspector, and Mr. H. C. Harbison, the botanist.

11. ENGLISH SPARROW (*Passer domestica* L.). Was introduced at Raleigh about 1879 or 1880, and by 1906 was present in all town localities, at least outside of the mountains. In 1905 and 1906 S. C. Bruner found none at Blowing Rock, but it had appeared there in 1907. In 1908 Mr. Sherman and myself found it still absent from Highlands.

12. SONG SPARROW (*Melospiza cinerea melodia* Wilson). Up to 1892 we had no records of this bird breeding anywhere in the State,

except on the northern half of the coastal banks, where it has been known to breed since 1870 (Coues); but since the former date it has been extending its breeding range southward in the mountains, till now it has become one of the commonest summer birds of the whole mountain region. Our knowledge of its progress is as follows: In 1892 three were seen frequently near Cranberry by Mr. Philip Laurent of Philadelphia during the summer of that year; in 1895 S. N. Rhoads found it common on Roan Mountain up to 3,500 feet; in 1902 Mr. T. G. Pearson saw two near Asheville in July (hitherto it had only been recorded as a winter visitor in Buncombe County by the late J. S. Cairns, up to his last known records (fall of 1894); in 1895 Oberholser records it as common in summer at Biltmore, and in the Pink Beds, Pisgah Forest; in 1906 S. C. Bruner finds it breeding at Blowing Rock; in 1907 Sherman observes the species in summer at Highlands and Hendersonville; in 1908 Sherman and myself found the bird in mid-May at Aquone, Highlands, and Blantyre; finally, in 1910, Sherman heard the species at Andrews in Cherokee County. Since then it has been found by Sherman, Bruner, Feild, myself, and others to be common in summer throughout Haywood, Buncombe, Madison, Mitchell, Yancey, Avery, and Watauga counties, and in that portion of Caldwell and Burke lying next to the mountains, all this area having been occupied by the species in the eighteen years from 1892 to 1910.

13. BLUEBIRD (*Sialia sialis* L.). Up to February, 1895, the bluebird was a common resident throughout the State, but in the first week of that month there came a period of sleet and snow which encased the bird's usual winter food (berries of various kinds) in a glittering sheet of ice, and the bluebirds, unable to obtain food, perished by thousands, and so complete and universal was the destruction that for some years afterwards it was quite an event to see a bluebird. Slowly, however, the species regained its numbers, and now is, so far as we can judge, about as common as formerly.

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Besides these more definite changes, I was informed a number of years ago, by Mr. R. B. McLaughlin, Jr., of Statesville, who was an observer of birds there during the early eighties, that when he first

paid attention to birds, the brown-headed nuthatch and hooded warbler were not known to breed near Statesville, but that a few years later both species had become regular breeders, and that the loggerhead shrike, which he found nesting there in his earlier years of observation, had vanished from that locality later on.

III. REPTILES.

1 YELLOWBELLIED TERRAPIN (*Pseudemys scripta* Schoippf). Some twenty-five years ago this species was only fairly common at Raleigh, and was about equal in numbers to the river terrapin (*Pseudemys concinna*). Now, however, the latter species has become much less common, while the yellowbellies have very greatly increased their numbers, so that now it is by no means a hard matter to get together fifty or a hundred at one time. It has also been taken at Greensboro, probably a recent extension of its range.

2. RIVER TERRAPIN (*Pseudemys concinna* Leconte). Frequents mostly running water, but even there seems to be now replaced by the preceding (at Raleigh).

3. TROOST'S TERRAPIN (*Pseudemys troosti* Holbrook). Mainly a Mississippi valley species, though I have had specimens from southwest Georgia, so that the taking of three specimens at Raleigh in 1914 and 1915 is of interest, and the future status of the species is a subject of conjecture.

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Another reptile, the banded rattlesnake (*Crotalus horridus*), although once ranging throughout the State, is now confined to the mountainous region of the west and the coastal swamps, while the alligator has been both reduced in numbers and restricted in range since early days; but we have no definite data in either case.

RALEIGH, N. C.

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